EXCESS DREDGING: IMPLICATIONS FOR NEGOTIATING ENVIRONMENTAL DOCUMENTS

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ABSTRACT

The USACE has long recognized in its development of technical guidance documents and regulations for channel design, dredging operations and contracting that there are inherent excavation accuracy limitations in the dredging process. As a result of dredging equipment capabilities and limitation, excess dredging will occur below the allowable overdepth within the context of the current standard of 1 to 2 foot allowable overdepth. The extent of excess dredging is influenced by the dredging equipment, as well as the physical characteristics of the material to be dredged (new work vs maintenance), the project physical conditions (tides, currents, waves, debris), channel design (water depth), and operator skill. Further the measurement precision of bathymetric surveys complicates defining the extent of any dredging in excess of the environmental documents and permits.

The primary purpose of this paper is to provide the dredging project manager seeking a dredging permit technical information and possible language to assist in negotiating a permit that is within dredging equipment capabilities. The use of the contractual definition of allowable overdepth as the permitted dredging limit often results in a permit requirement that is impossible for standard dredging equipment to meet. It can also impose an additional financial burden on the project that is not justified based on the related environmental impacts.

The suggested remedy to avoid problems of permit compliance, and excessive overdredging is to accept the fact of dredging depth accuracy (or inaccuracy) in both the permit and the dredging contract. The permit language can then be crafted to limit excess dredging to isolated, small areas. There is the need to develop permit language that addresses the regulatory concern(s), yet allows areas of excess dredging that will occur from a combination of equipment characteristics, operator skill and project physical conditions. To meet these goals, the allowable overdepth for permit compliance (as reflected in the final project survey) could be measured in one or a combination of the following ways (excluding side slopes):

- Limiting excess dredging based on volume, either as a percentage of the total project or as a percentage of the allowable overdepth not dredged.
- Limiting excess dredging based on area, as a percentage of the total project area, excluding slopes.
- Limiting excess dredging based on average depth, weighted by area.

Key Words: Dredging, allowable overdepth, excess dredging, permits.

INTRODUCTION

The primary purpose of this paper is to provide the dredging project manager seeking a dredging permit technical information and possible language to assist in negotiating a permit for both environmental and navigation projects that is within dredging equipment capabilities. The use of the contractual definition of *allowable overdepth* as the permitted dredging limit often results in a permit requirement that is impossible for standard dredging equipment to meet. It can also impose an additional financial burden on the project that is not justified based on the related environmental impacts.

The USACE and dredging project estimators have always differentiated between required dredging depth, allowable overdepth dredging and excess dredging, when preparing dredging designs, contracts, cost estimates and calculating disposal area capacity. Dredging depth, allowable overdepth and excess dredging are contract terms governing pay versus non-pay dredging. The value of these contract terms vary depending upon project goals and conditions. Recently, the term allowable overdepth is being used in environmental documents as a regulatory limit. The design allowable overdepth is being interpreted as the maximum depth of sediment disturbance without considering dredging equipment capabilities or limitations, and project conditions. All of which contribute to the extent of

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excess dredging or the actual total depth of bed disturbance and sediment removal on a particular project. From a regulatory perspective, allowable overdepth and excess dredging have become interchangeable; however when allowable overdepth is defined in permits as 1 foot, an allowance for excess dredging beyond the allowable overdepth is necessary.

The following definitions are excerpted from USACE documents and Figure 1 illustrates these terms for a typical section.

- Required Depth. The required depth is the specified minimum project depth that the owner requires to be obtained for the dredging event. The contractor must obtain this depth to meet the contract requirements for performance and payment. The contractor is usually penalized for not excavating material above this depth. The contractor may be required to either return to the area for additional, inefficient, dredging or to pay a penalty.
- Allowable Overdepth (traditional contract definition). Allowable overdepth dredging (depth, width and slope) is construction contract terminology for dredging that occurs outside the contract's required depth prism for which the contractor will be paid. This allows the contractor to achieve the required dredging depth and to be compensated for work required due to inaccuracy of the dredging operation while applying efficient dredging practices. The Contractor can dredge any, all or none of this overdepth under the terms of the contract without penalty.
- Excess Dredging (Non-pay dredging). This is dredging outside the paid allowable overdepth. This occurs as a result of such factors as equipment capabilities, project conditions, and operator skill. In general excess dredging occurs in small isolated areas and is not a significant project factor. It is this minor excess dredging, that this paper seeks to address in environmental document language that is acceptable to the regulator, the owner and the dredger.

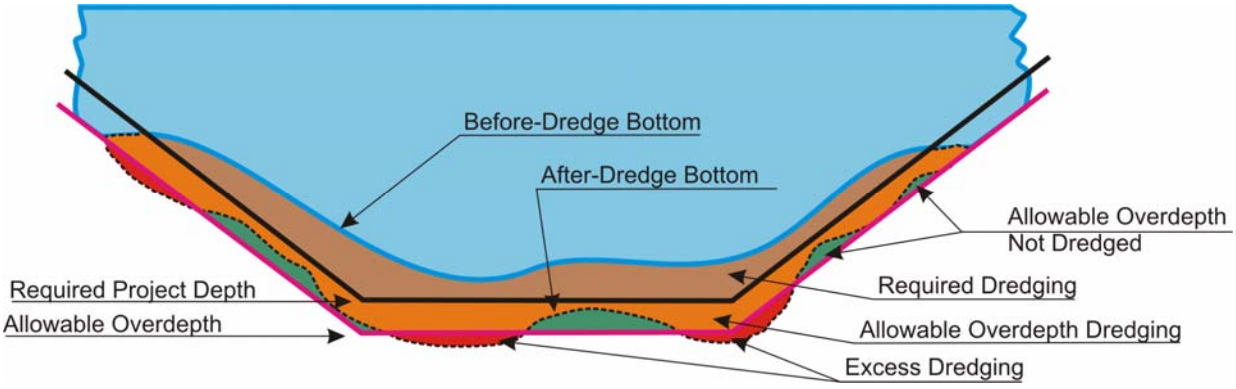

Figure 1. Dredging terms.

In negotiating regulatory language to define permit compliance, it is important to understand the potential impacts/consequences the regulator is attempting to avoid by the permit language. As the authors, Fisher and Ury, state in "Getting to Yes" a key element of successful negotiations is to create options that will satisfy both parties. The dredging project manager wants permit language that allows standard dredging equipment to excavate the project and comply with the permit language. The regulator wants to protect the environment. The owner wants the work completed at a reasonable price with no environmental impact. The challenge is to limit excess dredging so that all three parties are satisfied.

The potential excess dredging issues that could concern the regulator for a dredging project can be divided into the following categories. These concerns will vary depending upon specific project conditions, but will fit into one of the following areas.

- Sediment Characterization. The depth of sediment characterization is a significant pre-dredging issue that is being addressed by a joint US Army Corps of Engineers/Contractor committee. The depth issue is whether the pre-dredge sediment characterization should be accomplished to the total depth of dredging, and therefore includes the excess depth as well as the required and the allowable overdepth volumes. Or

does the definition for adequately characterized sediment include just the allowable overdepth elevation of dredging.

- Volume. Disposal area capacity is often a limited and valuable resource, especially for upland sites. The regulator seeks to protect that resource and avoid impacts of another upland site by limiting the dredging volume. The owner seeks to protect that upland disposal resource as well, but for monetary reasons as well as environmental. An inwater site may also have limited capacity to either contain or disperse the dredged material.
- Area. Allowable overdepth can be viewed by some regulators as a way the owner seeks to obtain a deeper project (i.e. circumventing the permitting process) and expects that if additional overdepth is permitted, then the resulting project will be excessively deeper throughout the project.
- Depth. Deep water holes artificially created by dredging can have potential dissolved oxygen, salt water intrusion, light penetration, and other environmental or habitat issues. In general these are significant issues for large deep areas, such as sumps or sand mining operations, not small isolated areas. The habitat impacts can vary depending on the location of the project.

For any or some of these concerns, regulators are appropriately reluctant to simply add another foot or two to the permitted allowable overdepth, thereby encouraging excessive dredging beyond the required project depth. The perception is that this will result in the gradual adjustment of a deeper project because the dredger will dig the entire contract allowed overdepth and treat the excess dredging allowance as the dredging equipment inaccuracy.

The suggested remedy to avoid problems of permit compliance, and excessive overdredging is to accept the fact of dredging depth accuracy (or inaccuracy) in both the permit and the dredging contract. The permit language can then be crafted to limit excess dredging to isolated, small areas. It has been expressed by regulatory agencies that a large cause for environmental concern occurs when the project sediment has not been adequately characterized. This has been interpreted to mean the sediment characterization within the area of the dredging has not been accomplished to a depth equal the depth of excess dredging. The goal becomes twofold. There is the need to develop permit language that addresses the regulatory concern(s), yet allows areas of excess dredging that will occur from a combination of equipment characteristics, operator skill and project physical conditions. To meet these goals, the allowable overdepth for permit compliance (as reflected in the final project survey) could be measured in one or a combination of the following ways (excluding side slopes):

- Limit the average project depth weighted by project area.
- Limit the percentage of project area that is deeper than the allowable pay overdepth.
- Limit the percentage of dredged volume from below the allowable pay overdepth relative to the total volume removed from the required prism plus the allowable overdepth prism.

Dredging accuracy is complicated by the fact that it is a process of excavating sediment that can't be seen from a floating (moving) platform. It is further complicated by the limits of surveying technology to measure the results of that dredging process.

FACTORS IMPACTING DREDGE EXCAVATION ACCURACY:

The following is a brief overview of the dredge equipment and project factors that impact vertical excavation accuracy. The factors that need to be considered when developing the environmental documents for a project are the same factors that the project designer considers when developing contract allowable overdepth and include:

- Blind working conditions mean that the operator cannot see where the dredge has already operated and has to rely upon his instruments and above surface observations for bucket or cutterhead positioning. Recent instrument/software innovations provide an increased level of accuracy to the dredging process but operator skill and progress surveys impact the ability to take maximum advantage of increasingly accurate instruments.
- Dredging equipment operational characteristics impact the ability to avoid excess dredging while obtaining the required dredging depth. The dredger must balance these demands. The more accurate the dredging requirements (i.e., the less allowable overdepth) the slower the dredging process and as a result the more expensive the dredging. In general, some excess dredging will occur regardless of how slow the dredging process is accomplished.

- Mechanical dredges excavate with a series of bucket bites that leave a series of imprints (scoops) on the bottom. The larger the bucket, the larger the scoop on the bottom. The dredger's challenge is not to leave any ridges between the bucket bites above the required dredging depth and limit the number of bites below the allowable overdepth. Fixed arm mechanical dredges have higher vertical accuracy than cable equipment and level cut buckets reduce potential over-dredging.
- Hydraulic dredges excavate by breaking and mixing the material with a cutterhead and pumping the slurry through the suction pipe at the cutterhead, through the dredge to a disposal site. The invert elevation of the cutterhead is below the invert elevation of the suction pipe. As a result, some of the disturbed material is not removed. The depth of that remaining disturbed material is dependent upon the type of material, volume of material sloughing off the cut bank in front or behind the dredge cutterhead, and the speed of the cutterhead rotation and swing. This impacts the potential for excess dredging, as well as the depth of disturbed material, depending upon the amount of allowable overdepth, the size of the cutterhead, the dredging depth (angle of cutterhead ladder), and the type of material.

♦ Project conditions

- Depth of cut bank impacts dredge operating efficiency. Shallow cut projects tend to have higher excess dredging volume as a percentage of the total project.
- Project physical characteristics, such as tides, wave conditions, and channel configurations. Tides, waves, and currents impact the elevation of the dredging platform and the operator must continually adjust for these changes. The less the stability of the dredging platform, the higher the potential for excess dredging.
- Material characteristics impact excess dredging volume. New work projects (first time dredged) will often include removal of debris and rock. This removal often leaves areas on the dredged bottom that may be below allowable overdepth. Routine maintenance dredging projects in loose material typically do not create conditions for this type of excess dredging.
- Debris and other obstructions in low frequency maintenance dredging projects (limited dredging events) can have significant debris or other obstructions on the bed. This is particularly true for waterways with shoreline industrial areas. Infrequent dredging will remove the debris, and may leave small areas of deeper bed elevations. Also, debris can impact the vertical alignment of the dredge cutterhead or bucket as the dredge hits the obstruction, which also results in deeper bed excavation over small areas of dredging.

♦ Operator skill and overall contractor effort such as frequency of quality control surveys, will also impact excess dredging.

All of these factors must be considered when determining the potential for excess dredging. Even on projects where sediment characterization is not an issue, excess dredging can be an important permit compliance issue. For example, if the public or another non-permitting agency opposes issuing a project permit, then excess dredging can become the basis for challenging the project. By negotiating limiting language into the permit that agrees with the contract, and accommodates the dredging process (i.e., excess dredging) the time and effort required to review and respond to a permit compliance complaint can be avoided. The most recent issue for excess dredging compliance enforcement has been primarily the issue of sediment characterization to match excessive dredging elevations. However, excess dredging has been a project issue distinct from sediment characterization for many years but has generally not been enforced. The issue of the permit requirements defining allowable overdepth as the equivalent of excess dredging depth is new.

ALTERNATIVES FOR DEFINING DREDGING LIMITS IN PERMITS

The amount of published data available to judge the limits of excessive dredging for permit language is small. The best guide, in addition to dredging experience for different equipment and project conditions, is historical surveys (pre- and post dredge) for the specific project.

Limit Excess Dredging to a Percentage of Project Volume

This can be calculated by measuring the volume of material dredged below the allowable overdepth depth and dividing it by the project volume (required dredging plus allowable overdepth).

Tavolaro and Weinberg (Tavolaro, 2006) recently analyzed overdepth dredging for eleven hopper dredge, backhoe dredge, and clamshell dredge projects. The dredges were operating in various types of materials (new work and maintenance) under various project conditions (deep draft, shallow draft, coastal entrance, and inner harbor). Based upon the Tavolaro and Weinberg (2006) study of mechanical and hopper dredge projects, excess dredging on new work dredging projects is approximately 10% to 15% of total volume (required depth plus allowable overdepth) and maintenance dredging projects is approximately 6%.

If the excess dredging volume is equal to or less than the allowable overdepth volume that is not dredged, then the disposal impact as a result of dredged material volume is unchanged. Tavolaro and Weinberg (2006) did not provide the volume of allowable overdepth that was not dredged in their study. On a recent cutterhead project in California, the excess dredging volume was less than the allowable overdepth volume not dredged. In terms of the disposal site impacts, this allows *credit* for the overdepth material that was not dredged against the excess dredging volume. It does not address the impact created for increased depth of dredging beyond the allowable overdepth.

Limiting permit language could be 1) excess dredging volume will not exceed x% of the project volume or 2) the volume of material removed below the required dredging depth of xx feet shall not exceed the calculated allowable overdepth. These two approaches are illustrated in Figure 2.

When evaluating excess dredging permitting language relative to volume consider:

- The project volume. The lower the overall project volume, the higher the relative percentage of excess dredging volume. For example, excess dredging of 500 CY is 10% of a 5,000 CY dredging project but 1% of a 50,000 CY dredging project. Therefore a project with a shallow bank cut (lower project volume) will require a larger excess dredging allowance, based on percentage of required volume.
- Allowable overdepth volume versus project volume or average depth of cut. A high percentage of allowable overdepth volume to the total project volume (required depth plus allowable overdepth volume) indicates a shallow cut and a lower percentage of overdepth volume that will likely remain after dredging. Resulting in less *credit* for available allowable overdepth not dredged to offset excess dredging.
- The amount of the allowable overdepth. For a project that allows 1-foot allowable overdepth, there will be significant excess dredging. But for a project with 2-feet excess dredging, there will be substantially less excess dredging for most projects.

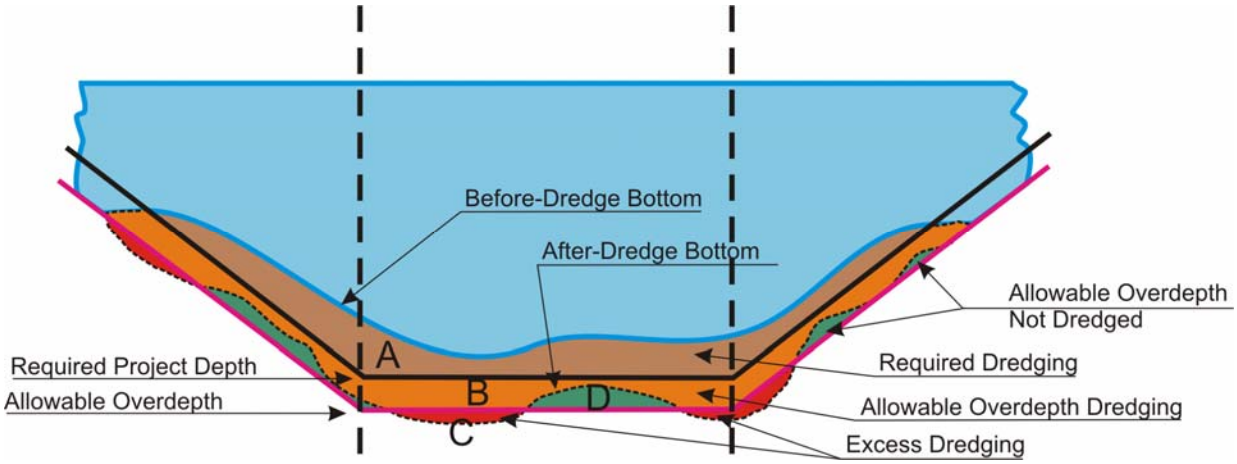

Figure 2. Illustration of alternative excess dredging language for volume where in 1) $C / (A + B) \leq x\%$ or in 2) $C + D \leq B$.

Limit Excess Dredging to a Percentage of Project Area

This is calculated by contouring the project and dividing the area deeper than the allowable overdepth by the project area (required + allowable overdepth.)

The advantage of limiting the total area of excess dredging is it provides the assurance that the purpose of including the excess dredging language in the permit is not to make a grab for a bigger project but rather to reflect the inaccuracies of the dredging process.

Limiting the Average Project Dredging Depth Weighted by Area

This is determined by calculating the average dredging depth of the area dredged to the required depth, to the area with excess dredging, and to the area with depths within the allowable overdepth: multiplying each depth by the percentage of the total area for that depth; and then finally adding all the values. For example, on a recent cutterhead dredging project the required dredging depth was -35 feet and 8.2% of the area (excluding slopes) was at -35 feet. The allowable overdepth was 1 foot and 82.4% of the project was at depths between -35 feet and -36 feet with an average depth of -35.6 feet. The remaining 9.2% of the project was deeper than – 36 feet (excess dredging) with an average depth of -36.3 feet. The average dredging depth weighted by depth is -35.6 feet,

((-35*.082)+(-35.6*.824)+(-36.3*.092) = -35.6)

less than the allowable overdepth of -36 feet.

INTERPRETING SURVEY DATA

The following information is based on the USACE engineering manual EM 1110-2-1003 Engineering & Design – Hydrographic Survey (1 January 2002, updated April 2004). "Hydrographic survey is unlike conventional terrestrial surveying in that there is no way to close out the traverse on a measured depth. Horizontal position is determined by an open-ended survey method (trilateration, triangulation, or traverse). The accuracy of the horizontal position is dependent on the precision of the measuring process and does not have an independent check. The depth measurement is referenced to the local water surface, which in turn must be referenced to a datum. The measurement method (mechanical or acoustic), sea state, water temperature and salinity, transducer beam width, bottom irregularity, bottom consistency, and vessel heave-pitch-roll motions all contribute to the depth measurement error."

Figure 3 is excerpted from Chapter 3 of EM 1110-2-1003 and provides the USACE hydrographic survey accuracy based upon equipment, project depth, and sediment characteristics.

As a result of these factors, hydrographic survey does not provide the level of accuracy of conventional terrestrial surveying. The inherent accuracy limits of hydrographic survey impacts how survey data should be interpreted for evaluating compliance with permitting and environmental documents. If the measurements provide a vertical accuracy of $\pm$ 0.25 to $\pm$2.0 feet, depending upon the project characteristics, then the measurements should not be used to measure environmental permit compliance in tenths of a foot.

Table 3-1. Minimum Performance Standards for Corps of Engineers Hydrographic Surveys (Mandatory)

PROJECT CLASSIFICATION		Navigation & Dredging Support Surveys Bottom Material Classification Hard	Soft	Other General Surveys & Studies (Recommended Standards)
RESULTANT ELEVATION/DEPTH ACCURACY (95%)				
System	Depth (d)			
Mechanical	(d<15 ft)	± 0.25 ft	± 0.25 ft	± 0.5 ft
Acoustic	(d<15 ft)	± 0.5 ft	± 0.5 ft	± 1.0 ft
Acoustic	(15>d<40 ft)	± 1.0 ft	± 1.0 ft	± 2.0 ft
Acoustic	(d>40 ft)	± 1.0 ft	± 2.0 ft	± 2.0 ft
OBJECT/SHOAL DETECTION CAPABILITY				
Minimum object size (95% confidence)		> 0.5 m cube	> 1 m cube	N/A
Minimum number of acoustic hits		> 3	3	N/A
HORIZONTAL POSITIONING SYSTEM ACCURACY (95%)		< 2 m (6 ft)	2 m (6 ft)	5 m (16 ft)
REPORTED FEATURE HORIZONTAL LOCATION ACCURACY (95%)				
Plotted depth location		2 m (6 ft)	5 m (16 ft)	5 m (16 ft)
Fixed planimetric features		3 m (10 ft)	3 m (10 ft)	3 m (10 ft)
Fixed navigation aids		3 m (10 ft)	3 m (10 ft)	3 m (10 ft)
Floating navigation aids		10 m (30 ft)	10 m (30 ft)	10 m (30 ft)
SUPPLEMENTAL CONTROL ACCURACY				
Horizontal Control		3rd order (I)	3rd order (I)	3rd order (I)
Vertical Control		3rd order	3rd order	3rd order
WATER SURFACE MODEL ACCURACY		[½ depth accuracy standard]		½ depth accuracy
MINIMUM SURVEY COVERAGE DENSITY		100% Sweep	NTE 200 ft or 60 m	NTE 500ft (150m)
QUALITY CONTROL & ASSURANCE CRITERIA				
Sound velocity QC calibration		> 2/day	2/day	1/day
Position calibration QC check		1/day	1/project	1/project
QA performance test		Mandatory	Required (multibeam)	Optional
Maximum allowable bias		± 0.1 ft	± 0.2 ft	± 0.5 ft

Figure 3. EM 1110-2-1003, Table 3.1.

CONCLUSIONS

Ignoring excess dredging, when negotiating permit language for dredging projects, and using contractual allowable overdepth as a limit for dredging depth often results in a permit that standard equipment cannot dredge in compliance. By inserting language that limits the excess dredging to meet the regulator's needs but allows standard dredging practices, the regulator, the owner, and the dredger win. Permit language alternatives could include the following:

- Limiting excess dredging based on volume, either as a percentage of the total project or as a percentage of the allowable overdepth not dredged.
- Limiting excess dredging based on area, as a percentage of the total project area, excluding slopes.
- Limiting excess dredging based on average depth, weighted by area.

Selecting an excess dredging compliance approach depends upon consideration of the project and equipment characteristics and the concern(s) of the regulator. What is the excess dredging impact that the regulator wants to avoid for this project? If the concern is a deeper project, limiting the excess dredging area may be appropriate. If

the concern is the disposal impacts, then limiting the excess dredging volume as a percentage of the total project or to an amount less than the allowable overdepth not dredged may be the appropriate choice. It is likely, that more than one concern may drive the regulator's choice and a combination of limits should be inserted into the permit language. The essential focus is the recognition that some excess dredging will occur on a dredging project.

At this time, excess dredging permit compliance issues are tied primarily to the depth of sediment characterization. This is an important issue and is being addressed by developing characterization standards. However, excess dredging has been a distinct issue with regulators for years and dredging project managers ignore it at their risk.

REFERENCES

Tavolaro, J. F., Weinburg, S. R., 2006, "An evaluation of overdepth dredging and its engineering and environmental implications: case studies from the northwest," Western Dredging Association XXVI Technical Conference & 38th Texas A&M Dredging Seminar, June 25-28, 2006, San Diego, CA.

U.S. Army Corps of Engineers, 1983, "Engineering and Design: Dredging and Dredged Material Disposal," Engineer Manual EM 1110-2-5025.

U.S Army Corps of Engineers, 1994, "Engineering and Design: Civil Works Cost Engineering," Engineer Regulation ER1110-2-1302, 58p.

U.S Army Corps of Engineers, 1996, "Project Operations: Navigation and Dredging Operations and Maintenance Policies," Engineer Regulation ER1130-2-520, 35p.

U.S Army Corps of Engineers, 1996, "Project Operations: Navigation and Dredging Operations and Maintenance Guidance and Procedures," Engineer Pamphlet EP1130-2-520, 108p.

U.S. Army Corps of Engineers, 2002, "Engineering and Design - Hydrographic Surveying" Engineer Manual EM1110-2-1003, 580p.